

Observations of the minor species Al, Fe and Ca⁺ in Mercury's exosphere

Thomas A. Bida¹ and Rosemary M. Killen²

¹ Lowell Observatory, 1400 Mars Hill Rd., Flagstaff, AZ 86001, USA

Corresponding author: tbida@lowell.edu

928-233-3209 (Tel), 928-774-6296 (FAX)

² NASA Goddard Space Flight Center, Greenbelt MD 20771, USA

rosemary.killen@nasa.gov

keywords: Mercury; Exospheres

Abstract. We report the first detections of Al and Fe, and strict upper limits for Ca^+ in the exosphere of Mercury, using the HIRES spectrometer at the Keck I telescope. We report observed 4- σ tangent columns of 1.5×10^7 Al atoms cm^{-2} at an altitude of 1220 km (1.5 Mercury radii (R_M) from planet center), and that for Fe of 1.6×10^8 cm^{-2} at an altitude of 950 km (1.4 R_M). The observed 3- σ Ca^+ column was 3.9×10^6 ions cm^{-2} at an altitude of 1630 km (1.67 R_M). A simple model for zenith column abundances of the neutral species were 9.5×10^7 Al cm^{-2} , and 3.0×10^8 Fe cm^{-2} . The observations appear to be consistent with production of these species by impact vaporization with a large fraction of the ejecta in molecular form. The scale height of the Al gas is consistent with a kinetic temperature of 3000 - 9000 K while that of Fe is 10500 K. The apparent high temperature of the Fe gas would suggest that it may be produced by dissociation of molecules. A large fraction of both Al and Fe appear to condense in a vapor cloud at low altitudes.

Introduction

A 4- σ detection of Al and Fe, and strict upper limits for Ca^+ in the exosphere of Mercury were measured at the Keck I telescope with the High Resolution Echelle Spectrograph in May of 2008 and 2009. A 4- σ tangent column of Al atoms of 1.5×10^7 cm^{-2} was measured at an altitude of 1220 km (3660 km from planet center, or 1.5 Mercury radii (R_M)) on 14 May 2008; and a 4- σ tangent column of Fe of 1.6×10^8 cm^{-2} was found at an altitude of 950 km (1.4 R_M) on 3 May 2009. The observed 3- σ upper limit Ca^+ column was 3.9×10^6 ions cm^{-2} at an altitude of 1630 km (1.67 R_M) on 080515, and 6.4×10^6 ions cm^{-2} at an altitude of 510 km on 090503. A simple model for zenith column abundances of the neutral species are 9.5×10^7 Al cm^{-2} , and 3.0×10^8 Fe cm^{-2} . The observations appear to be consistent with impact vaporization of surface material with a large fraction of the ejecta in molecular form. The derived temperature of the Al gas is about 3000 - 9000 K while that of Fe is 10500 K, although the temperatures are not well constrained because of limited spatial coverage.